Project Report

Canada/Yukon

Conservation and

Renewable Energy

Demonstration Agreement

Yukon
Retrofit training
Curriculum

Foreword

Yukoners import $90 million worth of refined hydrocarbons each year. This figure represents nearly $4,000 for every man, woman and child, and it further represents a staggering burden upon the economy of Yukon. There are no simple ways to reduce the burden of our dependence upon oil but there are ways to make a beginning.

Space heating consumes 35% of our energy bill. It is not unreasonable to say that it is possible to cut in half our annual fuel bill of $30 million for space heating. It is possible, it is desirable and it is needed, but it will not be accomplished unless the owners of the buildings being heated are informed and motivated and unless the tradespeople performing the retrofits are trained in the theory and practice of energy efficient building techniques and then, in their work, carry through on their training.

We recognize that to train the builders without altering the awareness of the consumers who, ultimately, will insure that the work is done properly is unwise and possibly irresponsible.

With this in mind, the Energy Branch, Government of Yukon, working with Yukon's Department of Education and Energy Mines and Resources, Canada, is developing a series of courses aimed at contractors, carpenters and consumers, with the goal of significantly improving the thermal retention characteristics of Yukon's buildings.

The curriculum presented in the following pages was developed as part of a residential retrofit demonstration project. Initiation and funding for the project came from the Conservation and Renewable Energy Demonstration Agreement (CREDA) between the Federal Government and Yukon. The course was developed by Renewable Energy in Canada and was delivered by them in April, 1983 in Whitehorse to 16 tradespeople and contractors.

Our immediate objective in the course was to guarantee that the work done on the CREDA retrofits (project description precedes the curriculum) was done to the highest possible standards. A secondary objective was to begin to develop a resource of building expertise hitherto unknown in this country.

It is a beginning only.

Pat Fraser,
Director, Energy Branch,
Government of Yukon.

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

Yukon
Department of Economic Development and Intergovernmental Relations

Project Summary: RESIDENTIAL RETROFIT DEMONSTRATION

Canada/Yukon Conservation and Renewable Energy Demonstration Program

Project No.
3766-4-25

Date:
November 22, 1982

Sectors:
Residential, Commercial

Project Locations:
Throughout Yukon

Technology:
Conservation

Project Manager:
Don Cozzetto
Yukon Housing Corporation

Status:
Initiated

Purpose:

1. To determine the cost effectiveness of a range of residential energy conservation measures under Yukon conditions.
2. To provide effective training in energy conservation theory and construction techniques for Yukon tradespeople and thence to provide employment opportunities.

Description:

One hundred residential dwellings and two apartment blocks will be selected for the program. Those Yukon residents who are recipients of the Pioneer Utility Grant will be eligible and the selection will be made on the basis of a lottery-type system to ensure distribution by geographical and housing type. The apartment blocks have already been chosen by the Yukon Housing Corporation. The residences will be divided into three groups and each group will receive progressively more comprehensive retrofit measures. In association with this aspect of the project a course for tradespeople has been designed and will be offered through the Yukon Vocational School under the auspices of Canada Manpower. The course will offer CGSB and YRS (Yukon Retrofit Standards) Certification to successful candidates and will acquaint them with retrofitting techniques, heating systems, moisture, air vapour barriers, insulation materials and design considerations including human physiology and the special needs of senior citizens.

Contributors:

Program Participants	$129,900
Yukon Housing Corporation	35,000
Canada	345,075
Yukon	115,025
Total	$625,000

Benefits and Savings:

1. Savings of between 20 and 90 per cent on fuel consumption depending upon the extent of retrofit measures taken.
2. Stimulus to the construction industry in Yukon. Approximately 328

person-weeks of employment will be generated by the project within the construction industry.
3. Preparation of skilled workforce in Yukon for future jobs.
4. Increased comfort levels due to air management, humidity control (low humidity is a contributing factor to chronic geriatric respiratory problems), and elimination of drafts and cold spots.

For More Information Contact:

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Economic Analysis:

Group 1: For an average cost of $950 per residence a savings of approximately 2000 litres of oil is expected. The simple payback calculation is just over one year.
Group 2: For an average cost of $3000 per residence a savings of approximately 2700 litres of oil is expected. The simple payback calculation is under 3 years.
Group 3: For an average cost of $10,700 per residence a savings of 3,800 litres of oil is expected. The simple payback calculation is under seven years.
Group 4: For an average cost of $53,500 per apartment block a savings of 59,000 litres of oil is expected. The simple payback calculation is four and one half years.

Monitoring and Evaluation:

Monitoring will consist primarily of before and after records of fuel comsumption. There will be before and after airtightness tests done in connection with thirty group 1 and group 2 homes' air sealings, and in addition, half of the group 3 homes will be tested using depressurization equipment after the work has been completed.

Other monitoring will include: before and after furnace efficiency testing, a by-product of the furnace servicing; a followup survey of the homeowners to determine their degree of satisfaction with the work performed.

Technical Details:

All homes in the sample will have been audited within the ECAP Pilot Project. The recommendations resulting from these audits will be used as a basis for selecting the homes to be included in the retrofit project and the specific work to be done on each home.
Group 1: Caulking and weatherstripping; depressurization tests on half the homes to determine leak locations including infiltration tests at 9 locations between 10 and 50 pascals both before and after sealing, the other half will be sealed without the aid of an infiltrometer to determine the cost-effectiveness of both methods of sealing a house; oil furnace servicing, downsizing of nozzle and retention head retrofit if required; installation of water flow restrictors and water heater blankets; other minor modifications as recommended by the Home Energy Survey; heat exchanger or fresh air feed where necessary.

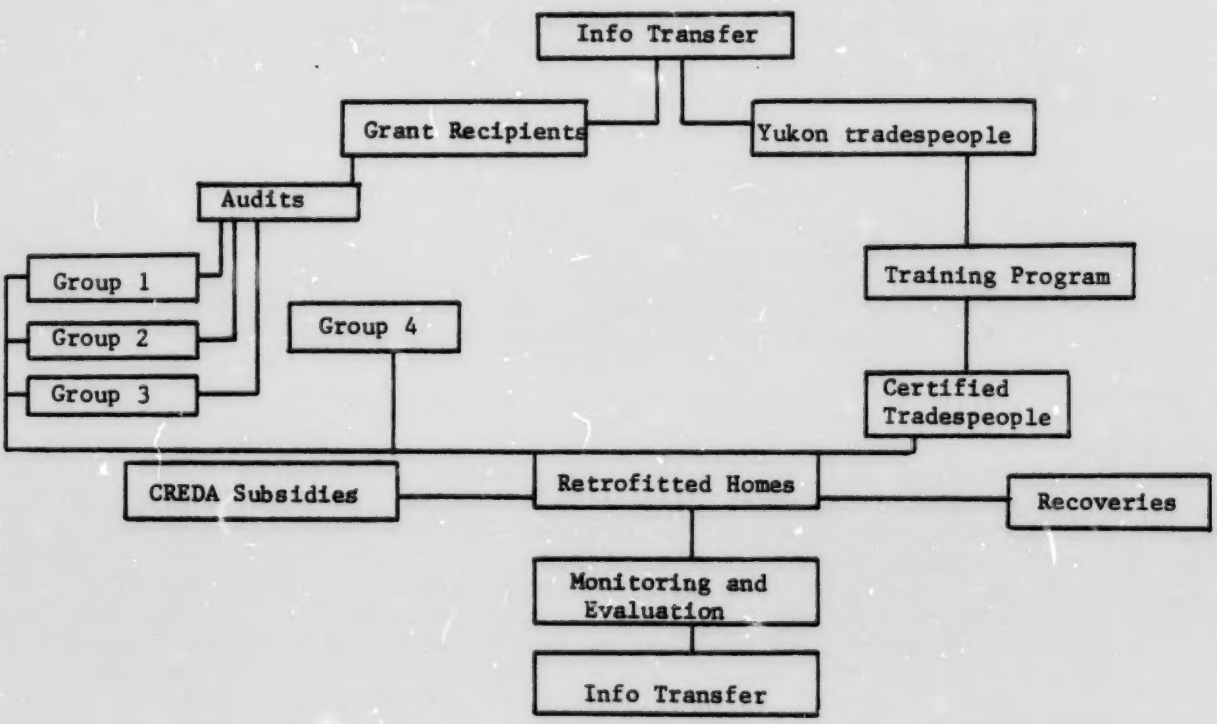
Group 2: All of the measures as for Group 1 plus: upgrading of attic insulation to recommended levels; installation of triple-paned windows; night set-back thermostats; other measures as recommended by the home energy survey.

Group 3: Total rewrap of the building shell; upgrading of heating system and conversion to non-oil, non electrical systems in one half of the Group 3 homes; DHW blankets and shower water flow restrictors; triple glazing; other minor modifications recommended by the home energy survey.

Group 4: One apartment block will be treated like the residences in Group 2. An older building attached to the first and a separate building will be treated like the buildings in Group 3.

Information Transfer Plan:

Information transfer will have three components: prior to the commencement of the project, a campaign to inform potential participants in the retrofit program and in the training program of the opportunities and benefits; accumulation of data and preparation of audio-visual aids for later uses; compilation and dissemenation of data, publications for specific target groups, seminars and press coverage.



Training: The Yukon Retrofit Certification Program

In addition to providing information on residential retrofits, it is proposed to utilize this project as a training ground for people who are interested in learning retrofit techniques.

The training component will be developed in conjunction with the Adult and Continuing Education Branch, Yukon Department of Education, and the Employment Development Branch, Employment and Immigration Canada. This component is crucial to the technical success of the project, and forms a major component of the project's information transfer as well.

Trades practices in the past have concerned themselves primarily with safety and structural soundness in the building, and, while adequately dealing with these very important issues have, shown insufficient attention to the energy related aspects in the design and construction. It is imperative that those performing the work be aware of the reasons for the methods used and the factors that have been taken into account in the design of each retrofit.

The training program will take a "hands-on" approach, with a mix of approximately one third theory, two thirds practical work being done directly on the project homes during the training period.

The training program will prepare local contractors for the CGSB certification examination, allowing them to perform retrofitting work under the federal CHIP and COSP programs.

The program will provide its own certification as well; and only those contractors who obtain this certification will be eligible to work on this retrofit project.

Course Overview

COURSE OVERVIEW

Introductory Session

The Retrofit Training Course is introduced in a two-day session. This block will encompass broad issues relating to the existing housing stock in Yukon and the potential benefits of energy conserving retrofit measures, thus providing an overview to the course participants of the relevance of the material which follows. Course participants will be made aware of the Residential Retrofit Demonstration Program and the link between this program and the course. The objectives of the course, schedules for delivery and requirements of the course participants will be provided.

During this introductory block, the course participants will also be required to gain an understanding of thermodynamic principles, heat loss mechanisms in the home, heat loss equations and energy inputs from heating appliances. This knowledge will allow the course participants to understand energy audit functions and to perform cost/benefit analyses. This information will be supplemented by a brief introduction to computer-assisted audits and heat loss analysis software.

The introductory segment of the course will prove important to the whole of the Retrofit Training Course. Throughout the next three weeks the course participants will be continually relating back to principles and concepts

addressed in this block. To ensure that the participants have fully understood the information presented, a brief test will be provided.

Low Level Retrofit

Within this four-day course block, the course participants will be familiarized with relatively low cost/rapid payback retrofit options. The focus of this block will be oriented towards providing the course participants with a working knowledge of the techniques and materials used in the air sealing of existing houses and background knowledge of improvements which can be made to the heating systems of these buildings. Further training will be provided detailing improvements to domestic hot water systems, potential reductions in electrical energy comsumption and suggested lifestyle alterations which can lead to energy and dollar savings.

This block of the Retrofit Training Course will be primarily focussed at the Level I retrofit applications being undertaken in the Residential Retrofit Demonstration Program. Course participants will gain a sound background in air leakage mechanisms, identification, depressurization equipment and techniques and materials for reducing infiltration and exfiltration from the building. Using a combination of in-class lectures, slide shows and on-site training, the instructors will ensure that the participants have obtained a thorough understanding of the field. Additional information regarding marketing and sales techniques will be provided during this course block. The course

participants will be familiarized with the costs and benefits of air sealing as well as with an understanding of the implications of air sealing on existing houses.

While the segments of this block relating to heating system improvements are by no means intended to train carpenters to perform furnace servicing, they will allow the course participants the opportunity of gaining a more thorough understanding of how the house heating system operates. Minor efficiency improvements in the distribution system, the potential improvements derived from nozzle resizing and sound maintenance practices will all be discussed and demonstrated.

This block of the course will conclude with a detailed discussion of the various products employed in residential retrofitting. The instructors will familiarize the course participants with the different products available for all aspects of residential retrofitting ranging from electronic control systems to insulation materials. The instructors will provide information relating to cost, durability, compatibility with other materials, best uses, limitations, installation procedures, and availability.

Through this block of the course the importance of air sealing as a component of any retrofit strategy will be stressed. Safety concerns relating to air quality, humidity control and adequate combustion air will be addressed to ensure that course participants understand potential problems which could

arise.

Medium Level Retrofit

Within this five day course block, the course participants will gain a theoretical knowledge and hands on experience of retrofit measures performed on the house interior. Measures to upgrade all aspects of the interior house envelope will be dealt with by the course instructors. This course block will provide an in-depth analysis of window heat loss and remedial measures and the potential benefits of window reorientation for solar optimization. Heat losses through foundation walls, basement slabs, slab on grade construction and crawl space applications and the associated retrofit measures will be thoroughly covered. Heat losses through attics, flat roofs and cathedral ceilings and any other roof configurations, retrofit measures and ventilation requirements will be discussed and demonstrated, as will wall heat losses and various retrofit treatments.

Throughout this course block, a balance will be struck between in class lectures and discussion and on-site, 'hands on', work. Course participants will be introduced to decision making criteria for each retrofit option, different retrofit strategies and various installation procedures. This will provide course participants with a thorough understanding of these retrofit measures and provide a basis for estimating and performing this work to provide the greatest energy savings in a profitable manner.

High Level Retrofit

Within this five and a half day course block, the course participants will gain a theoretical understanding and hands-on experience of exterior insulation retrofit techniques. The course participants will be introduced to decision-making criteria - when an exterior approach to house retrofitting is best justified.

This session will be evenly divided between in-class presentations and on-site application of exterior retrofit techniques. A sample house will be used as a teaching model with all class participants being involved in all aspects of an exterior super-insulation of a typical Yukon house - upgrading walls, upgrading roofs and optimization for solar gains.

Course participants will also learn costing of exterior reinsulation, labour implications and potential energy savings resulting from this work. Implications of high level retrofit work on air quality will be discussed as will be remedial strategies and air to air heat exchangers. An overview of high efficiency heating systems and furnace sizing for low energy houses will be provided.

Summary

The last two days of the Residential Retrofit Training Course will address new house construction and design techniques and the business side of contract retrofitting. A full day session detailing energy efficient techniques for new house construction will be presented. The final day of the course will address the subject of sales and marketing of energy efficient retrofits and new housing and will provide an overview of alternative financing for energy efficiency. A review of government assistance programs will be presented. The last afternoon of the course will be devoted to evaluation of the course participants, and course wrap-up.

Conclusion

The Residential Retrofit Training Course is intended to provide course participants with a thorough training in the field of energy conserving retrofits. It is intended that those participants successfully completing the course be thoroughly qualified to evaluate and perform all aspects of home energy conservation relating to the building envelope. Participants will also be able to specify improvements to home heating systems and air management systems. Course participants should rank amongst the most qualified retrofit contractors in the country.

Daily Overview

DAILY OVERVIEW

Day 1: Course Introduction

Day One material will provide the course participants with a general overview of the course, and of the need for providing retrofit measures on Yukon housing. The morning session will provide the course participants with a schedule for the course duration. The instructor will acquaint the participants with the different topics to be covered, the type of on-site work to be performed, and the requirements of the participants - both in class and on site. The session will focus more directly on the need for retrofitting the existing housing stock in Yukon. The course participants will be introduced to the benefits of energy-conserving technologies - both the potential energy and dollar savings as well as the 'softer' benefits such as increased comfort and reduced noise levels inside the home. The instructor will present an overview of Yukon housing stock and the broader picture of Yukon energy futures as they relate to the residential sector.

Course participants will be introduced to the importance of providing quality work - ensuring that energy savings are not attained at the expense of structural integrity or at the expense of upset homeowners. A brief overview of the importance of a sound marketing strategy and good client relations will be provided. An overview of the Residential Retrofit Demonstration Program will end the morning session.

The afternoon session will provide course participants with a basic understanding of thermodynamic principles. Convection, conduction, and radiation will be explained as they relate to comfort levels within the house and to broader heat loss equations. Throughout the morning session the course instructor will focus on de-mystifying some of the more technical information. Psychrvometric charts will be explained as they relate to condensation of water vapour on windows and in wall sections. Vapour permeability of materials will be addressed as a mechanism for reducing vapour passage. The session will deal with applied theory as it relates to retrofit technologies.

The ability of different materials to slow the flow of heat will be addressed. The course instructor will outline the abilities of insulation and other building materials, air sealing techniques, reflective surfaces, glass and still air in restricting thermal transfer.

Day 2: Heat Loss Mechanisms and Energy Auditing

The first session of Day Two will provide the course participants with an understanding of heat loss equations. The participants will become familiar with different units of energy which are required in performing heat loss equations. The participants will be familiarized with British and Metric Units and will be provided with understandable conversion tables. The session

will enable the participants to perform detailed heat loss calculations on individual components of the building or on the dwelling as a whole. The instructor will deal with the subjects of energy costs, heating system efficiency, fuel conversion factors, etc. which will allow the participants to translate heat loss into dollars and cents.

The second morning session will also provide course participants with a broad understanding of heat loss routes in the average Yukon house. An average house will be analysed for heat losses through walls, ceilings/attics, windows, basements/crawl spaces, doors, and infiltration, showing percentage losses through each aspect of the house envelope. This session will provide a sound introductory base for the audit session in the afternoon.

The afternoon of Day Two will familiarize the course participants with energy audit procedures and an overview of the economics of house retrofitting. This session will ensure that the participants have acquired a sound understanding of heat loss mechanisms within the house and can perform detailed analyses of individual houses.

The session will focus on different auditing procedures. Participants will be introduced to the basics of manual audit procedures as well as computer assisted audits. A demonstration audit will be performed to better acquaint the participants with the techniques. The participants will be made aware of the importance of communication skills in maximizing the potential success of

any audit-like work. Auditing equipment and procedures will be outlined ranging from walk-through versions to highly instrumented and computerized versions.

Day 3: Low Level Retrofits and Air Leakage

Day Three will look closely at the economics of retrofitting existing houses. The course participants will become familiar with extraneous costs associated with retrofitting i.e., residing, renovation work. The concept of incremental costing will be addressed. The session will also begin to look at potential savings to be accrued from retrofit techniques. General rules of thumb for priorization of retrofit measures will be introduced. Course participants will be provided with a basis for decision-making relating to which level retrofit is most applicable for a given house. The concept of three distinct levels of retrofit will be presented through case studies, offering the participants examples of documented energy savings and cost/benefits.

The second morning session will introduce the course participants to the field of air sealing. The instructors will deal with the mechanisms of air leakage into and out of the house - wind pressure, stack effect and diffusion. The course participants will be familiarized with the avenues of air leakage in average housing and different means of leak identification. Different analysis techniques, both simple and instrumented, will be presented.

Course participants will be introduced to fan depressurization techniques in the afternoon of Day Three. This will include installation and operation, calibration of pressure differentials, and relevance of readings @ 50 PA to any seasonal air change rates.

The afternoon session will be divided between an on-site demonstration and further in-class discussion. The class will witness the installation and operation of a depressurization fan on a sample house and then will participate in a leakage identification tour of the building. This site visit will also be used to reinforce auditing techniques addressed in Day Two. No on-site work will be performed during this visit.

Day 4: Air Sealing-2

Day Four will lead into air sealing techniques and materials, providing course participants with 'hands-on' experience in houses. The first block in the morning will be devoted to an in-depth discussion of materials used in air-sealing and installation procedures. Course participants will be introduced to different products and will learn relative costs, best uses, compatibility with other products, installation procedures and safety considerations.

The second block of the morning and first block of the afternoon will take place on-site. Course participants will identify leaks in a sample house, and

then use the materials and techniques discussed in the morning to seal the house. All participants will be involved in air sealing the different components of the building envelope. The sample houses will be pressure tested both before and after the retrofit work to provide the participants with a gauge of their performance.

The second block in the afternoon will summarize air-sealing techniques. Different aspects of the house envelope not seen at the sample house will be analysed - different roof sections, basements, construction techniques - to provide the course participants with perspectives on differing housing types.

Job costing will be summarized at the end of this session. Average time requirements, skill of crews, cost of materials, and overhead costs will be discussed. Business approaches, sales and marketing and client relations will be discussed.

Day 5: Heating Systems

Day Five will focus on upgrading existing heating systems within the house. The interaction of retrofit work and heating systems will be discussed in the morning session. The course participants will be introduced to the mechanics of heating systems - forced air, hydronic and radiant heaters. Distribution systems and potential efficiency improvements will be addressed. The morning session will focus on a 'house doctor' approach, analysing the distribution

system. Zone controls, system balancing, taping of ductwork and set-back controls will be identified and discussed.

The first block of the afternoon session will provide an overview of furnace efficiencies and measures for ensuring high operating performance. Improvements outlined will include nozzle downsizing, installation of retention heads, solenoid valves, and flue dampers. The role of a qualified furnace serviceman will be outlined. A brief discussion of replacement options will be discussed.

The second block of the afternoon will take place on-site. Course participants will tour a house and take part in a 'house doctor' program. A furnace efficiency test will be performed and alterations will be made to the system to improve efficiency.

Day 6: Wood, DHW, Products

Day Six will address potential improvements to wood fired appliances and to the domestic hot water systems of the house. A general overview of products and materials used in energy conserving retrofits will be discussed in the afternoon session.

The first block of the morning will address both existing and new wood heating systems. Topics to be addressed will include efficiency improvements,

installation, safety, operation, combustion air supply, and domestic hot water pre-heating.

The second morning block will address domestic hot water systems, from both the demand and supply perspective. Retrofit techniques for reducing hot water demand will be discussed, including low flow shower heads and flow restrictors. Improvements to the efficiency of DHW heaters and distribution systems will be covered. These will include: heat traps, DHW insulating blankets, pipe insulation, burner efficiency, thermostat controls, point of use water heaters, and pre-heat mechanisms.

The first block of the afternoon session will summarize low level retrofit measures. Requirements of the contractor and implications for the homeowner will be reiterated.

The second afternoon block will provide an overview of the products and materials used in energy-efficient construction. Different materials and products will be analysed under the criteria of cost, availability, performance, durability, best use, disadvantages and safety implications. The overview will provide a basis for decision making for all retrofit measures, which will follow in the medium and high level segments of the course.

Day 7: Windows

Day Seven of the Retrofit Training Course will begin with an introduction to medium level retrofit strategies and the topics to be discussed and demonstrated during this block of the course. This introduction will be followed by an in depth analysis of window heat loss mechanisms and various retrofit strategies.

Heat loss mechanisms through windows - conduction through sash, frames and across glass; convection and air leakage around the sashes of the window and through the frame; and radiant heat losses through the glass will be addressed. Air sealing of windows which will have been discussed and performed in the low level retrofit section will be reiterated. A discussion of window operation for new installations will highlight the potential energy savings derived from reduced crack areas.

Upgrading the glazing of existing windows will be discussed during the second block of the morning. Adding fixed thermopane units to the window opening, additional panes to operable windows and the benefits of interior and exterior storm windows will be examined. Discussion as to the relative merits of double, triple and quadruple glazing will lead to an examination of the relative costs of different window upgrading strategies.

The first block of the afternoon session will provide information about moveable insulation systems. Design criteria (edge seal, operability, vapour permeability, R value, etc.), commercial and custom insulating systems will be

addressed.

The last segment of Day Seven will be on-site applications of retrofit window strategies, allowing course participants hands-on experience.

Day 8: Solar/Basements

Day Eight will be divided between a morning session detailing solar optimization, and an afternoon session introducing basement heat loss principles and interior retrofit strategies.

The two morning blocks will address solar insulation, window orientation, and passive solar retrofit measures. Course participants will be introduced to sun path charts, solar insolation data, energy balances through windows at various orientations and slopes and thermal capacity of various materials. Downsizing and increasing the size of windows to maximize solar gains and minimize heat loss will be explained as it relates to both interior and exterior retrofit techniques. Solar retrofit strategies - sunspaces, solar greenhouses and other retrofits - will be analysed from a cost/benefit perspective.

The afternoon sessions will focus on heat losses through foundation walls, concrete slabs and crawl space installations. Conductive and convective losses through this aspect of the building envelope will be detailed.

Concerns about moisture and vapour passage will be addressed. The course participants will be introduced to various retrofit options for reducing heat losses through basements and crawl spaces. Reinsulating options, dealing with electric and plumbing penetrations and reducing floor losses will be presented as an introduction to on-site work on the following morning.

Day 9: Basements

Day Nine will provide further information to the course participants regarding basement retrofit techniques. The morning session will consist of hands-on work in a sample house demonstrating different retrofit measures on the house basement. Rigid foam insulation, cross-strapping and new frame wall construction will be performed on different walls to provide a more clear understanding of job costing, labour requirements and potential energy savings.

The afternoon block will be devoted to an in-class presentation and discussion of exterior insulation of foundation walls. Installation procedures, different material options, finishing details, protective coverings and cost/benefits will be discussed. Weather permitting, this work will be performed on one of the candidate houses for the Level 3 Residential Retrofit Demonstration Program. This session will be presented as an adjunct to the high level retrofit block from Day Thirteen to Seventeen.

Day 10: Roofs/Attics

Day Ten of the Retrofit Training Course will focus on the thermal upgrading of attics, flat roofs and cathedral ceilings. Heat loss mechanisms through these elements of the house will be examined with a view to moisture control and ventilation requirements.

Course participants will learn reinsulation techniques for conventional attics - installation of vapour barrier, blown in or batt insulation, removal of recessed ceiling fixtures, detailing around plumbing stacks and chimneys and ventilation requirements.

Similar detail will be provided for the particular problems caused by flat roof houses and cathedral ceilings. Reinsulation techniques to be outlined will include different measures for increasing cavity spaces (cross-strapping, hanging extension rafters, etc.). Providing adequate space for continuous soffit to peak ventilation will be discussed.

The afternoon session of day ten will provide course participants with hands-on experience with the techniques illustrated during the morning block.

Day 11: Walls

Day Eleven will focus on the upgrading of the walls of the house from the

interior. The instructor will address different wall strategies ranging from rigid board insulation through to reframing walls. Specific details for extending window and door jambs, extending electric switch and outlet boxes, and dealing with plumbing fixtures will be addressed. The course participants will also learn options for resealing and insulating bad joist cavities between floors.

Major emphasis throughout this block - as throughout the medium level retrofit segment - will be directed towards air/vapour barrier installation, aiming at continuity of installation. Details of air/vapour barriers at windows, doors, electric outlets and sealing at seams will be carefully explained. Alternative options for ensuring long term integrity of air/vapour barriers will include cross strapping, air barrier boxes for electric outlets, etc. Costs and labour implications of the various options for upgrading walls of houses will be discussed.

The afternoon block of day eleven will consist of on-site hands-on application of various wall retrofit options.

Day 12: Summary of Medium Level/Introduction to High Level

Day Twelve will conclude the medium level retrofit session and introduce the concept of high level retrofitting. The first block of the morning will be devoted to a review of case studies of interior retrofits across Canada. This

review will analyse techniques employed, costs incurred, energy savings and cost benefit findings, providing course participants with an overview of retrofit potential.

The second block of the morning will be devoted to an in-class assignment evaluating the course participants' understanding of the materials learned in the medium level retrofit block. This test will allow the course instructors to assess their ability to effectively transfer technical information, and the students' competence in performing medium level work.

The afternoon course block will introduce course participants to the field of high level retrofits. Initially, decision making criteria for determining when exterior insulation is best suited will be discussed. The course instructor will review air-vapour barrier installation and theoretical dew point calculation in introducing the concept of house rewrapping. A slide presentation of examples of rewrapped houses will illustrate these concepts in application. Finally, course participants will be introduced to the implications of a thorough exterior house retrofit - increased humidity levels, reduced ventilation of fresh air, lack of combustion air, and reduced demand on heating systems and associated oversizing issues.

Day 13

Day Thirteen will provide course participants with the beginning of a step by

step approach to exterior insulation. The next three days will focus on the rewrapping of a sample house, allowing course participants to be actively involved in all aspects of curtain wall and roof reinsulation.

The first block of the morning session will be held in class. (Site preparation will be discussed initially. Concerns about electrical service, oil pipes, window and door casings, telephone cables, etc., will be addressed.) The session will provide course participants with a thorough understanding of air/vapour barrier installation on the outside of existing houses. Principles of dew point location, installation procedures, sealing techniques, stability of materials under exposure to ultra-violet radiation and installation durability will be addressed.

The second block will detail alternate framing techniques. Calculation of dead loading on base plate details, different plate details, Larsen Truss Systems, alternative framing options and cost and labour implications will be assessed.

The afternoon of day thirteen will take place on site. Course participants will perform a visual survey of the house and analyse the different retrofit options and their applicability. Hands-on work will begin with installation of the air/vapour barrier and the base support plate.

Day 14

Day fourteen will be divided between morning in-class work and afternoon on-site application.

The first block of the morning will address the issue of windows and doors. Relocation as part of an exterior retrofit and solar optimization will be discussed. Installation of new windows and framing details will be detailed, as will techniques for extending jamb and sill details to the new curtain wall. Course participants will understand the importance of proper rain run-off from recessed openings.

The second morning block will address the issue of rewrapping a house roof. Removal of soffits and rafter extensions, air/vapour barrier placement and protection, installation of roof stand-offs, laying new rafters, reinsulation, resheathing and finishing details will be discussed and demonstrated.

Afternoon sessions will be held on site. New framing of the exterior walls and framing of a small roof section will be performed. Depending on the course instructor's evaluation of the situation, several different wall sections could be addressed. Ideally course participants will be divided into smaller groups of five, allowing each group to perform work on a section. Timing will be the determining factor in this exercise.

Day 15

Day Fifteen will begin with a brief in-class review of exterior reinsulation techniques and then move directly to the construction site. On this day framing will be finished, some insulation will be installed, the small roof section will be insulated and sheathed and a section of the wall will be taken to a finished state.

Day 16

Day Sixteen will address implications of the exterior retrofit option on both the contractor and the homeowner. The first block of the day will analyse job timing and job costing. Requirements of labourers, the need for site supervision, quality control, job pricing and cost/benefits will each be analysed and discussed.

The second morning block will provide an overview of exterior retrofit techniques being used across Canada and the U.S. A slide presentation detailing different case studies - costs, energy savings, etc. - will be provided. Problem areas and issues will be highlighted.

The afternoon sessions will focus on the issue of air quality and the potential for remedial air management strategies. The first block will address the issues of air quality and combustion air in an air-tight house. The buildup of contaminants, odours, humidity, and their affect on occupant

health and comfort will be analysed and discussed. Low-cost remedial strategies - opening windows, humidistat controlled ventilation, source ventilation, and dummy chimneys will be analysed as to their reliability.

The second afternoon block will address the subject of air-to-air heat exchangers. Theory, installation, and operation will be discussed. Potential problems and trouble shooting will also be addressed. Course participants will be introduced to an operating manual for cold climates.

Day 17

Day Seventeen will address the issue of heating systems in both retrofitted and new housing. The morning sessions will focus on high efficiency heating systems. The course instructors will analyse different oil, propane and electric-fired heating systems as they relate to housing with a small demand load. Efficiency improvements in heat distribution and air circulation will be discussed.

The session will also focus on control mechanisms, set back thermostats, and humidistat controls from a cost/benefit perspective. Heat storage will also be discussed from an efficiency and cost basis.

The first afternoon block will look at monitoring and evaluation procedures for new house and retrofit construction. Time constant testing, fan

depressurization testing and more simple evaluation of fuel consumption will be addressed.

The final section of Day Seventeen will serve as a review of all of the retrofit material discussed throughout the course. This will serve as a final check of the course particpants' grasp of the theories, materials and techniques addressed over the duration of the course.

Day 18

Day Eighteen will be devoted entirely to new house construction. Most of the theory, concepts and information which formed the foundation of the course will be reviewed as they relate to new housing.

The first morning session will deal with design consideration. Course participants will learn principles of orientation, site planning, floor planning to enhance interior occupancy and best building shapes to enhance energy performance.

The second morning block will address design options for different foundation options. Pressure treated foundation, block walls and poured concrete will be evaluated from a cost and energy efficiency perspective. Detailing of air/vapour barrier sealing around electrical panels, and plumbing service inlets and outlets will be discussed.

The afternoon session will focus on alternative wall and roof framing options. Double stud wall and web trusses, wrap and strap techniques and masonry wall construction. The course instructor will analyse the various framing and insulation options from an energy efficiency perspective. Interior requirements for additional thermal mass relating to south window area will be discussed, as will be the merits of multiple glazing layers and window insulation techniques.

The final session will introduce the course participants to the differences in low energy construction when compared to conventional construction. Thermal performance, costs, and implications and ordering of trades will be discussed in detail. A summary discussion on air quality and heating systems will conclude the session.

Day Nineteen

Day Nineteen will conclude the Residential Retrofit Training Program. The morning session will introduce effective sales and marketing techniques to the course participants to ensure that their technical knowledge is put to extended use. Literature from successful operations in southern Canada will be demonstrated as to their effectiveness.

The second morning block will address financing assistance programs for

retrofit work. Course participants will be introduced to requirements of the various assistance programs and accessing the programs. Programs introduced will include but not be limited to CHIP, COST, RRAP, and all relevant YTG programs. A summary of The Residential Retrofit Demonstration Program will be provided.

The afternoon will serve as an evaluation section. Course participants will write the CGSB senior estimators test and a summary test on the RRTC.

General Objectives

RRTC Day 1: 8:15 - 12:00

GENERAL OBJECTIVE: This unit will be introductory by nature, acquainting students with the Retrofit Training Program and its potential value for Yukon Housing.

SPECIFIC OBJECTIVE: #1

Given this section, the student will understand and gain a working knowledge of:

- The Residential Retrofit Training Program
- The importance of quality control on the work site
- The benefits of energy conservation both in economic and less tangible terms
- The state of Yukon's housing stock and retrofit potential
- Future energy supply and demand projections as they relate to economic and lifestyle expectations
- The Residential Retrofit Demonstration Program

RRTC

Day 1: 1:00 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an understanding of "Heat Loss" and the effects it can have on "Human Comfort".

SPECIFIC OBJECTIVE: #1

Given this unit, the student will be able to:

1. Correctly define:
   a) energy (potential and kinetic)
   b) forms of energy
   c) heat energy
   d) temperature
   e) conduction
   f) convection
   g) radiation
   h) water vapour
   i) theoretical dew point
   j) R values
   k) U values
   l) degree days

2. Correctly explain the role of insulation, air barriers and vapour retardants in restricting heat transfer

3. Correctly perform theoretical dew point calculations for a given wall assembly

4. Correctly state conversion factors from British to Metric SI

5. Correctly determine relative energy content of fuels

RRTC Day 2: 8:15 - 10:00

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an understanding of "Heat Loss" and the effects it can have on "Human Comfort".

SPECIFIC OBJECTIVE: #2

Given this unit, the student will be able to:

1. Correctly define: a) infiltration
   b) air change rate
   c) Equivalent Leakage Area

2. Understand and correctly provide:

   a) explanation of relative heat losses through different components of an average house

   b) explanation of variances in percentage heat losses in different housing types, configurations and ages

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of "Heat Loss" and the effects it can have on "Human Comfort".

SPECIFIC OBJECTIVE: #3

Given this unit, the student will be able to:

1. Given construction details, correctly calculate heat loss factors for a given structure

2. Correctly calculate energy savings resulting from various retrofit measures

3. Correctly calculate wattage, heat loss per degree-day and seasonal heat loss

4. Given energy costs, correctly calculate dollars spent on heat loss from residential buildings

5. Correctly explain the manner in which insulation and air/vapour barriers restrict heat loss

RRTC Day 2: 1:00 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of Energy Auditing and Energy Economics.

SPECIFIC OBJECTIVE: #1

Given this unit, the student will be able to:

1. Correctly explain the functions of an energy audit
2. Correctly explain the strengths and weaknesses of energy audit procedures
3. Perform competent homeowner interviews drawing essential information about homeowner needs and motivation
4. Perform an audit as an educational tool
5. Evaluate different housing types

RRTC Day 3: 8:15 - 10:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of Energy Auditing and Energy Economics.

SPECIFIC OBJECTIVE: #2

Given this unit, the student will be able to:

1. Correctly define:
   a) cost/benefit
   b) fuel escalation
   c) present value
   d) incremental cost
   e) marginal return

2. Correctly perform sample payback calculations

3. Address the relative merits of different retrofit strategies (i.e., low, medium and high level)

4. Discuss different case studies of retrofit measures in Canada

RRTC

Day 3: 10:15 - 12:00
1:00 - 2:45

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an understanding of Air Leakage in the house

SPECIFIC OBJECTIVE: #1

Given this unit, the student will be able to:

1. Correctly define:
   a) infiltration
   b) exfiltration
   c) stack effect
   d) wind pressures
   e) vapour diffusion
   f) neutral plane

2. Correctly explain the mechanisms of air leakage into and out of the house

3. Correctly state the major sources of air leakage in typical housing

4. Correctly explain the reason for air sealing as a first step in retrofit activities

5. State correctly the difference between calibrated air leakage at 50 PA. and seasonal air leakage

6. Understand the operation of a depressurization fan

7. State correctly the potential for reducing air leakage in different housing types

RRTC Day 3: 3:00 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an understanding of Air Leakage in the house.

SPECIFIC OBJECTIVES: #2

Given this unit, the student will be able to:

1. Prepare a house for a calibrated air leakage test
2. Correctly identify major air leakage locations in a sample house
3. Correctly perform on-site audit work

RRTC Day 4: 8:15 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an undersanding of Air Leakage in the house.

SPECIFIC OBJECTIVES: #3

Given this unit, the student will be able to:

1. Understand the relative cost/benefit of different air sealing products

2. Correctly choose caulking and weatherstripping materials for different aspects of the house envelope

3. Perform thorough air sealing of all aspects of sample houses

4. Complete job estimate forms - labour requirements and materials inclusive

5. Correctly explain the potential implications of air sealing on:
   - humidity
   - air quality
   - combustion air fan

6. Correctly priorize air sealing measures to meet a fixed budget

RRTC Day 5: 8:15 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of the implications of low level retrofit work on existing heating systems and the potential for improving heating system efficiency.

SPECIFIC OBJECTIVE: #1

Given this unit, the student will be able to:

1. Correctly define:
   a) peak efficiency
   b) seasonal efficiency
   c) system balancing
   d) zone heating
   e) damper controls
   f) combustion chamber
   g) heat exchanger
   h) plenum
   i) return air
   j) combustion air
   k) stack, chimney and damper
   l) stack temperature

2. Explain the implications of reduced heating demands on existing home heating systems

3. Explain the inefficiencies resulting from oversized heating systems

4. Analyse heat distribution systems in typical houses

5. Perform efficiency improvements to heat distribution systems in a sample house

6. Calculate the energy savings resulting from set-back thermostats

7. Recommend to the homeowner potential efficiency improvements of existing heating plant

8. Explain the main steps of a furnace efficiency test

RRTC Day 6: 8:15 - 12:00

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an understanding and awareness of retrofit measures for wood burning appliances and domestic hot water systems.

SPECIFIC OBJECTIVE: #1

Given this unit, the student will be able to:

1. Correctly define: a) controlled combustion air
   b) secondary air
   c) creosote
   d) anti-syphon loop
   e) stand-by losses

2. Correctly explain the requirements of energy-efficient solid fuel burning appliances

3. State the causes of creosote formation

4. Perform efficiency improvements to existing fireplaces

5. State the importance of exterior combustion air intake for wood burning appliances

6. Correctly explain the retrofit options for domestic hot water systems

7. Calculate pay back for DHW retrofit options

8. Correctly priorize retrofit options for DHW to a given budget

RRTC

Day 6: 1:00 - 3:00

GENERAL OBJECTIVE: Upon completion of this unit students will have gained an awareness of products used in residential retrofitting

SPECIFIC OBJECTIVE: #2

Given this unit, the student will be able to:

1. Evaluate the cost/benefits of different insulation and retrofit materials in specific applications

2. State the relative energy performance of different retrofit strategies

3. Explain the relative health and safety precautions to be employed with different retrofit techniques

4. Explain the characteristics of different retrofit materials including: their flammability, permeability and insulating qualities

RRTC

Day 6: 3:00 - 5:00

GENERAL OBJECTIVE: This unit will be used to ensure that students have gained a thorough understanding of low-level retrofit measures. A test of the material covered in Day 1 - Day 6 will be issued.

RRTC Day 7: 8:15 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of heat loss through windows, and remedial retrofit measures.

SPECIFIC OBJECTIVE:

Given this unit, the student will be able to:

1. Correctly explain the three heat loss mechanisms through windows : conduction, convection and radiation

2. Correctly calculate conductive heat loss through single, double, triple and insulated windows

3. Perform correct window retrofit work:
   - adding interior storms
   - adding fixed glass

4. Correctly explain the features of an effective movable insulation system

5. Correctly state the cost/benefit of different window retrofit techniques for a sample window

6. Correctly state safety concerns to be addressed with movable insulation systems

7. Correctly state proper installation procedures for new windows to reduce air infiltration

8. Correctly explain the causes of condensation on glazing, and remedial measures

9. Correctly state caulking materials compatible with fixed glazings

RRTC

Day 8: 8:15 - 12:00

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an understanding of passive solar retrofit concepts and techniques.

SPECIFIC OBJECTIVE:

Given this unit, the student will be able to:

1. Correctly define:
   a) insolation
   b) angle of incidence
   c) absorbtivity
   d) reflectivity
   e) thermal mass
   f) thermal capacity
   g) temperature swings

2. Correctly perform a sun path chart analysis

3. Correctly determine the amount of solar energy entering a given window at different orientations

4. Correctly state rules of thumb for thermal mass requirements per given area of south facing glass

5. Determine cost-effectivness of different passive solar options

6. Present several options for sun control/sun shading

RRTC

Day 8: 1:00 - 5:00
9: 8:15 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit the student will have developed an understanding of heat loss through basement walls and floors and remedial retrofit techniques.

SPECIFIC OBJECTIVE:

Given this unit, the student will be able to:

1. Correctly define:
   a) hydrostatic pressure
   b) soil pressure
   c) adfreezing
   d) spalling
   e) water table
   f) thermal gradients
   g) capillary action

2. Correctly explain the insulating value of soils surrounding the house.

3. Correctly state moisture management practices for basement walls
   - water leakage
   - vapour penetration

4. Calculate heat loss through foundation walls, floor slabs, and crawl spaces

5. Correctly state structural implications of interior and exterior basement retrofit work

6. Correctly determine the cost/benefit of different basement and crawl space retrofit techniques

7. Correctly perform basement re-insulation work

8. Provide a detailed job estimate for both exterior and interior retrofit of basements and crawl spaces

RRTC Day 10: 8:15 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of heat loss through attics, flat roofs and cathedral ceilings, and the various retrofit techniques.

SPECIFIC OBJECTIVE:

Given this unit, the student will be able to:

1. Correctly calculate heat loss through different roof assemblies

2. State correctly the minimum requirements for attic and roof ventilation

3. Correctly explain the requirements for attaining a good air/vapour barrier seal in attics

4. Correctly state the benefits and disadvantages of different retrofit options:
   - rigid board
   - cross strapping
   - rafter extension
   - blown-in insulation

5. Correctly perform different retrofit techniques

6. Determine the cost/benefit of different retrofit techniques for house attics and flat roofs

7. Perform a job cost sheet for different techniques on a sample roof section

RRTC Day 11: 8:15 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of heat loss through existing house walls and the various interior retrofit strategies.

SPECIFIC OBJECTIVE:

Given this unit, the student will be able to:

1. Calculate heat loss through different wall assemblies

2. Correctly explain the benefits and disadvantages of different wall retrofit techniques:
   - rigid board
   - cross strapping
   - interior wall framing
   - blown-in insulation

3. Correctly explain vapour barrier installation detailing around electrical boxes, plumbing fixtures, etc.

4. Correctly explain the potential problems resulting from the use of polyethylene as an air-barrier in a house with intermittent occupancy

5. Correctly perform different wall retrofit techniques

6. Determine the cost/benefit of different retrofit techniques for walls

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of "Exterior Reinsulation" principles and installation techniques.

SPECIFIC OBJECTIVE:

Given this unit, the student will be able to:

1. Correctly state the requirements of vapour barrier placement on exterior walls to ensure structural stability and thermal efficiency

2. Correctly calculate the amount of exterior insulation required for sample wall sections

3. Correctly explain site preparation required for exterior retrofit

4. Correctly state installation procedures for exterior basement insulation: - rigid polystyrenes
   - rigid fibreglass

5. Correctly state and perform vapour barrier installation for exterior retrofit

6. Correctly state location of base plate assembly for different housing types

7. Correctly state two different curtain wall framing techniques

8. Correctly explain and perform rough framing and finishing of jamb extensions around windows and doors

9. Correctly explain and perform reroof installation

10. Correctly state safety precautions to be employed when performing an exterior reinsulation of walls and roofs

11. Correctly state the requirements of zoning by-laws which might affect exterior reinsulation work

12. Correctly calculate energy savings resulting from exterior reinsulation techniques

13. Perform a job cost estimate of an exterior retrofit on a sample house

RRTC Day 17: 8:15 - 12:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of "Residential Heating Systems".

SPECIFIC OBJECTIVE:

Given this unit, the student will be able to:

1. Correctly calculate the delivered cost to the homeowner of heat from different fuel sources
2. State the features of high efficiency condensing furnaces and boilers
3. Calculate correctly the cost/benefits of installing a high efficiency combustion unit
4. State correctly the importance of proper furnace sizing
5. Explain alternative heating systems for low energy housing
6. Correctly explain the operation of thermostat set-backs and humidistat controls
7. State correctly requirements for house flues and chimneys when changing fuels for combustion units
8. State correctly concerns which need to be addressed when considering construction of a thermally isolated furnace room

RRTC Day 17: 1:00 - 2:45

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understarding of 'Monitoring and Evaluation' techniques.

SPECIFIC OBJECTIVE: 1

Given this unit, the student will be able to:

1. Calculate correctly seasonal heat loss from fuel records using degree day data

2. Explain correctly time constant test procedures and weaknesses

3. Correctly state the relevance of pressure testing to seasonal heat loss

4. Correctly explain the usefulness of humidity readings within the house

RRTC

Day 17: 3:00 - 5:00

GENERAL OBJECTIVE: This unit will be used to ensure that students have gained a thorough understanding of high-level retrofit measures. A test of the material covered in Day 12 - 17 will be issued.

RRTC Day 18: 8:30 - 12:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of energy efficient construction techniques for new residential buildings and the implications of these construction practices on the building structure and occupancy.

SPECIFIC OBJECTIVE: #1

Given this unit, the student will be able to:

1. Operate a computer assisted heat loss analysis design program
2. Analyse different framing techniques allowing for increased insulation levels
3. Detail alternative air-vapour barrier options to attain air tightness
4. Outline different options for improving thermal performance of windows
5. Correctly state requirements for controlled air management and heating systems for low energy housing

RRTC

Day 18: 1:00 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of energy efficient construction techniques for new residential buildings and the implications of these construction practices on the building structure and occupancy.

SPECIFIC OBJECTIVE: #2

Given this unit, the student will be able to:

1. Correctly state the implications of low energy construction on timing of sub trades and supervisory requirements

2. Correctly calculate the extra costs incurred in low energy construction as compared to conventional construction

3. Correctly calculate payback periods for increased insulation levels and air tightness

4. Understand alternative sales and marketing approaches to low energy housing

RRTC Day 19: 8:30 - 5:00

GENERAL OBJECTIVE: Upon completion of this unit, the student will have developed an understanding of effective marketing and sales approaches to energy efficient retrofit work.

SPECIFIC OBJECTIVE: #1

Given this unit, the student will be able to:

1. Understand the importance of client relations
2. Understand the main components of an effective marketing strategy
3. State alternative financing schemes being employed to enhance the sales of low energy retrofits
4. State correctly the various government assistance programs relating to energy retrofits

Daily Summaries

Re .ential Retrofit Training Course — Timetable for Week I

Time	8:15 - 10:00	10:15 - 12:00	1:00 - 2:45	3:00 - 5:00
TUESDAY	ENERGY CONSERVATION AND HOUSING			
	Course Overview	Yukon Housing & Energy Fixtures	Applied Thermodynamics	Terminology
WEDNESDAY	HEAT LOSS MECHANISMS AND ENERGY AUDITING			
	Heat Loss Equations	Heat Loss in Yukon Homes	Auditing Principles	Auditing Techniques
THURSDAY	LOW LEVEL RETROFITS AND AIR LEAKAGE			
	Economics of Retrofitting/ Case Studies	Mechanisms of Air Leakage	Fan Depressurization	On-site
FRIDAY	AIR SEALING			
	Materials and Techniques	On-site	On-site	Advanced Techniques Costing/ Implications of Air Sealing

Residential Retrofit Training Course — Timetable for Week II

Time	8:15 - 10:00	10:15 - 12:00	1:00 - 2:45	3:00 - 5:00
MONDAY	HEATING SYSTEMS			
	Interaction of Retrofit and Heating	House Doctoring	Furnace Efficiency	On-site
TUESDAY	WOOD, DHW & PRODUCTS			
	Wood Fired Systems	Domestic Hot Water	Low Level Summary	Product Overview
WEDNESDAY	WINDOWS			
	Heat Loss Mechanisms	Upgrading Glazing	Moveable Insulation	On-site
THURSDAY	SOLAR RETROFITS/BASEMENTS			
	Solar Data	Solar Retrofits	Basement Heat Loss	Interior Retrofits
FRIDAY	BASEMENTS			
	On-site	On-site	Exterior Insulation	Job Costing

[redacted] Timetable for Week III

Time	8:15 - 10:00	10:15 - 12:00	1:00 - 2:45	3:00 - 5:00
MONDAY	ATTICS AND CEILINGS			
	Heat loss mechanisms/ Ventilation	Retrofit options	On-site	On-site
TUESDAY	INTERIOR WALLS			
	Materials and Techniques	Framing Job Costing	On-site	On-site
WEDNESDAY	SUMMARY/HIGH LEVEL RETROFIT			
	Summary of Medium level Retrofit		Exterior Insulation Principles	Basement Review
THURSDAY	AIR VAPOUR BARRIER/FRAMING			
	Air Vapour Barrier	Framing details	On-site	On-site
FRIDAY	EXTERIOR INSULATION			
	Extending jambs	Roof insulation	On-site	On-site

R dential Retrofit Training Course — Timetable for Week

Time	8:15 - 10:00	10:15 - 12:00	1:00 - 2:45	3:00 - 5:00
MONDAY	EXTERIOR INSULATION			
	On-site	On-site	On-site	On-site
TUESDAY	EXTERIOR/AIR QUALITY			
	Case studies Problem are	Timing/Costing	Air quality/ Humidity Combustion Air	Heat exchangers
WEDNESDAY	HEATING SYSTEMS/SUMMARY			
	High Efficiency Heating	~~Monitoring~~ Control/Distribution	~~New house construction~~ Monitoring/Evaluation	Summary of high level retrofit
THURSDAY	NEW HOUSING			
	House Design	Structural & Framing Details	Alternate Systems	Labour Costs Implications
FRIDAY	WRAP UP			
	Sales/Marketing	Relevant grant programs		Wrap up

R.R.T.C. DAILY SUMMARIES DAY ONE

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Course Outline	Yukon Housing and Energy Futures	Applied Thermodynamics	Terminology
Audio-Visual	General Intro. (Slides)	What Not To Do (Slides)	Slides	
Handouts	Course Material Bibliography	Yukon Statistics Soft Energy Paths for Yukon	'R' values Permeance ratings Psychrometric charts	Conversion table Energy content of fuels Glossary of terms

References: International Building Thermographic Training Course
From the Walls In; Charles Wing
Condensation in the Home; CMHC
Canadian Building Digest; NRC
The Complete Book of Insulating; Larry Gay

Assignments: Readings
Sample Take off of House Measurements

R.R.T.C. DAILY SUMMARIES DAY TWO

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Heat Loss Equations	Average heat loss mechanisms	Auditing principles	Auditing Techniques
Audio-Visual		Slides Model House	Slides	Computers
Handouts	Sample charts	Quiz	Standard audit forms ECAP Enersave Hotcan	

References:

Canadian Building Digest; National Research Council
Energy Consumption and Conservation Patterns in Canadian Households
Proceedings; Building Toward 2001 Conference
Residential Conservation Service Auditor Training Manual; U.S. Department of Energy

R.R.T.C

DAILY SUMMARIES

DAY THREE

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Economics of Retrofitting	Mechanisms of Air Leakage	Fan Depressurization	On-site
Audio-Visual	Case Studies (slides)	Slides		
Handouts	Payback calculations Case Study retrofit information	Weatherizing survey Leak locations kit Alberta Caulk and Weatherstrip	Tables and Ranges Caswell Hull Study	

References:

CGSB Manual for Air Sealing Contrators
Lawrence Berkeley Laboratory Study
A Survey of Current Research into Air Infiltration in Buildings; Air Infiltration Centre
Thermographic Evaluation of Airtightness Work in Residential Buildings; S. Moffatt

Assignments:

Provide recommended Retrofit measures for Sample House

R.R.T.C. DAILY SUMMARIES DAY FOUR

	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Air Sealing Materials and Techniques	On site Air sealing	On site Air Sealing	Advanced Techniques Job costing
Audio-Visual	Slides			Slides
Handouts	CGSB air sealing Job Estimate Forms Consumer Reports First, Seal Your House			Can. Am. Retrotech

References: CGSB Air-Sealing Manual

Assignment: Readings

R.R.T.C. DAILY SUMMARIES DAY FIVE

	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Interaction of Retrofit and Heating Systems	'House Doctoring'	Furnace Efficiency	On site efficiency improvements
Audio-Visual	Slides			
Handouts	Bill Payers Guide	Making the Most of Your Heating System	Energy Efficient Oil Heating	COSP information
		House Inspection Form		
References:				

Assignments: Analyse Heating System of own House
Visit Sample House in Teams
Prepare Presentation to Class

R.R.T.C.		DAILY SUMMARIES		DAY SIX
	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Wood fired systems	Domestic hot water	Summary of low level retrofit	Product overview
Audio-Visual	Slides	Slides		
Handouts	- safety - CMHC - BTU of wood - Fireplace Factsheet - Bibliography	- Pellini	- Bibliography	- Products catalogue - summary charts - supplies
References:	Heating with Wood - Safely; CMHC Heating with Wood; PEI The Canadian Wood Heating Book; Flagler The Woodburner's Encyclopedia; Shelton			
Assignments:	Test on low level work			

R.R.T.C. DAILY SUMMARIES DAY SEVEN

	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	- medium level intro. - heat loss through windows	Upgrading Glazing	Moveable insulation	On-site application
Audio-Visual	Slides		Slides	
Handouts	- mechanism of heat loss	Detailed drawings	- commercial systems - plans for D.I.Y. - Harrowsmith	

References: Moveable Insulation; W. Langdon
Thermal Shades and Shutters; W. Shurcliffe
Window Design Strategies for Energy Conservation; NBR
CBD #17. Insulated Window Shutters, June 1980

Assignments: Prepare presentation on What To Do in Sample House
Readings

R.R.T.C. DAILY SUMMARIES DAY EIGHT

	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Solar Data	Solar Retrofits	Basements - heat loss mechanism	Interior Retrofit
Audio-Visual		Slides		Slides
Handouts	- solar insolation data - equations - sun path chart	- detail drawings	- CGSB - Mitalis/NRC	

References: Solarizing Your Home; Ed. Joe Carter
The Solar Retrofit Book; Ed Mazria
Passive Solar Design Manual for Alaska; R. Siefert
Wintergreens; M. Craft
Insulation Retrofit of Masonry Basements; J. Timusk

Assignments: Prepare debate on Pros and Cons of Solar in Yukon
Do Sun Path Chart for Sample House

R.R.T.C. DAILY SUMMARIES DAY NINE

	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	On-site	On-site	Exterior insulation	Job costing
Audio-visual			Slides	
Handouts			Detail drawings Manufacturer's Specs.	Costing Sheets

References: Insulation Aftermath; J. Eykes

Assignment: Job Costing/Energy Savings of Interior vs. Exterior Basement Retrofit

R.R.T.C. DAILY SUMMARIES

DAY TEN

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Heat losses through attics/ceilings	Retrofit options	On site	On site
Audio-visual		Slides		
Handouts	- R values installed insulation - ventilation requirements	- detailed drawings - flat roofs - problems		

References: C.G.S.B. Manual For Insulation Contractors
Super-Insulated Retrofit Book
Complete Book of Insulating
D.B.R. ISSN 0701-5216, Energy Conservation and Roofs
Canadian Building Digest #176

Assignments: Job Costing
Readings

R.R.T.C. DAILY SUMMARIES DAY ELEVEN

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Materials and Techniques	Alternative Framing Costing	On-site	On-site
Audio-Visual	Slides			
Handouts	SRC material Conserve When You Renovate	Detail Drawings		
References:	Conservahome Pt. 1 and 2 Super-Insulated Retrofit Book; Argue/Marshall Keeping the Heat In; EMR Insulation Aftermath; Jon Eykes			
Assignments:	Test of Medium Level Retrofit Techniques			

R.R.T.C.		DAILY SUMMARIES		DAY TWELVE
Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Summary of Medium Level	Evaluation	Introduction to High Level Retrofit	Implications Site Preparation
Audio-Visual	Film (Old House, New House)		Slides	Slides (What Not To Do)
Handouts	Ecology House Info. Summary Sheets	TEST	Dumont/Orr NRC Paper	
References:	Super Insulated Retrofit Book; Argue/Marshall			

R.R.T.C.

DAILY SUMMARIES

DAY THIRTEEN

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Overview	Air/Vapour Barrier Installation	Framing Options and Details	On-site V.B. Installation	On-site Framing Base Plate
Audio-Visual	Slides	Slides		
Handouts	Source list of U.V. stabilized polyethylene	Larsen Truss Info. ERG. Detailed Calculation of loading Detail drawings		

References: Super Insulated Retrofit Book; Argue/Marshall Conservahome Series; Saskatchewan Government

R.R.T.C. COURSE OUTLINE DAY FOURTEEN

Item	a.m. 8:15 - 10:30	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Framing Windows and Doors Extending Jambs Installation of New Windows	Roof Re-wrapping	On-site Framing Windows/Doors Jamb Extensions	On-site Wrap Roof Section
Audio-Visual	Slides	Slides		
Handouts	Detail Drawings	Detail Drawings Loading Calculations		
References:	Super Insulated Retrofit Book; Argue/Marshall			

R.R.T.C. COURSE OUTLINE DAY FIFTEEN

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	In-class review	On-site Frame Roof	On-site Frame Roof Insulate	On-site Sheathing Bldg. Paper
Audio-Visual	Slides			
Handouts				
References:	Super-Insulated Retrofit Book; Argue/Marshall			

R.R.T.C. DAILY SUMMARIES DAY SIXTEEN

Item	a.m. 8:15 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Job Timing Job Costing Quality Control	Problem Areas Case Studies Energy Overview	Air quality Combustion Air	Air to Air Heat Exchangers
Audio-Visual		Slides		Slides
Handouts	Materials List Pricing Sheets	Summary Sheets	Fresh Air and Humidity	Mfg. Literature

References:
Air to Air Heat Exchangers; W. Shurcliffe
Air-to-Air Heat Recovery Devices for Small Buildings; Alaska D.O.T.
A Survey of Current Research into Air Infiltration in Buildings; Air Infiltration Centre

R.R.T.C. DAILY SUMMARIES DAY SEVENTEEN

Item	a.m. 8:30 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	High Efficiency Heating - oil system - electric heating - high-eff. propane - new wood installation	Controls/ Distribution - thermostats - balancing the system - safety features	Monitoring/ Evaluation - time constant - pressure test - seasonal monitoring	Summary of High Level Retrofit - overview - problems
Audio-Visual	Slides	Slides		Slides
Handouts	Make the Most of Your Heating System		Sample worksheets	

References: Efficient Residential Oil-Heating Systems
The Super-Insulated Retrofit Book

Assignments: Readings

R.R.T.C. DAILY SUMMARIES DAY EIGHTEEN

Item	a.m. 8:30 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Low Energy House Design	Foundation and Basement Insulation	Alternative Wall and Roof Systems	Labour and Cost Implications
Audio-Visual	Slides	Slides	Slides	
Handouts	Energy Efficient Housing: A Prairie Approach	Detailed Drawings	Alternative Framing Options NRC - Low Energy Housing	Enerplan: MOE Low Energy Housing Survey Construction Cost Analysis

References:
Double Shell and Super Insulated Houses: W. Shurcliffe
Well Tempered House: R. Argue
Energy Conservation and Passive Solar Building Costs for Alaska; James Barkshire
Arctic Home Construction and Insulation Techniques; Alaska Council on Science and Technology
Air Vapour Barriers; D. Eyre and D. Jennings

Assignments: Review

R.R.T.C. DAILY SUMMARIES DAY NINETEEN

Item	a.m. 8:30 - 10:00	a.m. 10:15 - 12:00	p.m. 1:00 - 2:45	p.m. 3:00 - 5:00
Course Outline	Sales and Marketing Energy Conservation	Financing Energy Conservation	Evaluation	Evaluation
Audio-Visual	Slides			
Handouts	Sample literature	gov't information - E.M.R. - Y.T.G. - C.M.H.C.	C.G.S.B. test	Course test

References: Marketing Energy Conservation; C.H.I.E.C.A.
Barriers to Implementing Energy Efficient Contruction; S.R.C.

Reference Materials

Residential Retrofit Training Course

Course Text Books : The Super Insulated Retrofit Book, R. Argue and B.Marshall, Renewable Energy In Canada, 1981

Insulation Aftermath, Jon Eykes, Ontario Marketing Products Ltd., 1982

Audio Visuals

The three audio visual presentations listed in the back were all prepared by Renewable Energy in Canada, 334 King Street East, Studio 208, Toronto M5A 1K8, (416) 947-9552. Slides and additional information may be obtained by contacting them

Reference Books

1. The Super-Insulated Retrofit Book; R. Argue and B. Marshall; Renewable Energy in Canada (1982).

2. The Complete Book of Insulating; Larry Gay; Stephen Breire Press (1980).

3. The Insulation Aftermath; Jon Eykes; Ontario Marketing Products Ltd. (1982).

4. Moveable Insulation; William Langdon; Rodale Press (1982).

5. Thermal Shades and Shutters; William Shurcliffe; Brick House Press (1982).

6. Insulation Retrofit of Masonry Basements; J. Timusk; Ontario Ministry of Municipal Affairs and Housing, Ontario (1982).

7. Handbook on Insulating Homes for Energy Conservation: CGSB Manual for Insulation Contractors, (1981).

8. Solarizing Your Present Home; ed. Joe Carter; Rodale Press (1982).

9. From the Walls In; Charles Wing; Atlantic, Little, Brown Ltd. (1979).

10. Energy Efficient Housing: A Prairie Approach; Sask. Mineral Resources (1980).

11. The Well-Tempered House; R. Argue; Renewable Energy in Canada (1980).

12. A Passive Solar Design Manual for Alaska; Richard Seyfert (1981).

13. Air to Air Heat Exchangers; William Shircliffe; Birch House Press (1982).

14. Low Energy Building Plans; Dept. of Energy, Alberta, (1983.

15. The Sensible Rehabilitation of Older Houses; CMHC (1975).

16. The Woodburner's Encyclopedia; Jay Shelton; Venncit Crossroads Press (1976).

17. Air/Vapour Barriers; D. Eyre and D. Jennings; Energy, Mines and Resources Canada (1982).

Periodicals

- Canadian Building Digest - National Research Council, Ottawa.
- New Shelter - Rodale Press, Emmaus PA.
- Fine Homebuilding - Taunton Press, Newtown CT.
- Super Insulation - MASEA.
- Renewable Energy News - Ottawa.
- Solar Age - SolarVision, Church Hill, N. H.

Review Materials

LOW LEVEL RETROFIT SUMMARY

1. Define correctly the following terms, and include at least one pertinent example:

   a) conduction -
   b) convection
   c) radiation
   d) water vapour
   e) theoretical dew point
   f) degree days
   g) watt
   h) air change rate
   i) equivalent leakage area
   j) stack effect
   k) neutral plane
   l) peak combustion efficiency
   m) seasonal combustion efficiency
   n) down sizing
   o) stack or flue temperature
   p) return air
   q) barometric damper

2. Explain the role of insulation in restricting the movement of air.

3. Explain the difference between an air barrier and an air/vapour barrier.

4. Given an interior temperature of 18°C and an outside temperature of -20°C, at a relative humidity of 25% ,where is the dew point location?

5. State the percentage heat losses occuring from the following locations in an average house.

   ceilings -
   walls -
   windows -
   doors -
   basements -
   air change -

6. State the factors which influence heat loss from the house interior.

7. Explain the functions of an energy auditor.

8. Given the following information, calculate the seasonal heat loss from a sample house in Whitehorse.

		RSI
Attics	75m²	5.5
Walls	80m²	2.0
Windows	7m²	.49
Doors	4m²	.3
Floor (above unheated crawl space)	75m²	2.1

   Volume = 187m³

   Air Change Rate = .6

9. Calculate the seasonal heating dollars required by a homeowner occupying the above home, and heating with an oil furnace at 65% seasonal efficiency. (one litre of oil has a maximum of .037 GJ)

10. State the three forces influencing air leakage rates in housing in order of priority.

11. State the average range of natural air change rates in existing houses.

12. What role does a depressurizing fan play in air sealing?

13. State the percentage reductions which can be achieved in air leakage in average housing.

14. What is the difference between natural air change rates and induced air changes at 50 pascal?

15. What are the major sources of air leakage in the average house?

16. What preparatory work should be undertaken before depressurizing a house?

17. Explain the best uses for the various caulking materials used in house sealing.

    a) butyl
    b) acrylic latex
    c) silicone
    d) polyurethane foam
    e) aconotical sealant

18. Explain the potential implications of air sealing on:

    a) humidity
    b) air quality
    c) combustion air

19. Explain the implications of reduced heating demand on home heating systems.

20. How do retention head burners work to save heating dollars?

MEDIUM LEVEL REVIEW

1. What are the three mechanisms of heat loss through windows?

2. State the reasons for improved performance of awning and casement windows over sliding or double hung windows.

3. Explain the benefits and disadvantages of interior and exterior storm windows.

4. Calculate the energy savings resulting from installing a triple glazed window in place of a 2 sq. m. single glazed unit.

5. Calculate the energy savings resulting from the use of an RSI 1.1 movable insulation system on a 2.5 sq. m. window for 10 hours daily using a 6000 DD climate.

6. State the basic requirements of an effective movable insulation system.

7. State three means of minimizing excess solar gains in housing.

8. Explain the benefits/disadvantages of sloped and vertical glazing as passive solar collectors.

9. State the usefulness of a sun path chart.

10. State the difference between moisture control and water control in house foundation walls.

11. What are the advantages/disadvantages of exterior vs. interior basement insulation.

12. Explain the relative merits of reinsulating with rigid foam boards vs. framing and batt insulation on interior walls.

13. What flashing requirements must be met when performing exterior basement insulation.

14. State two options for air sealing a crawl space application.

15. Why can heat loss through house roofs be greater than through walls?

16. Explain the importance of proper attic ventilation.

17. Calculate the potential energy savings per square metre resulting from the installation of RSI 3.2 over an attic currently insulated to RSI 1.8. Using electricity priced at 7¢/kWh, calculate the dollar savings in a 100 m^2 attic.

18. State two means of reinsulating cathedral ceilings and explain the relative benefits and disadvantages of each approach.

19. Detail proper air-vapour barrier installation between floors in retrofitting.

20. State the advantages and disadvantages of the following materials as air-vapour barriers:

    . polyethylene
    . builders foil
    . Tyvek
    . enamel paint

21. Calculate the energy and dollar savings resulting from the addition of RSI 3.5 to a 20 m^2 wall currently insulated to RSI 2.1 in a climate with 6000 DD.

HIGH LEVEL RETROFIT REVIEW

1. What type of house provides easy justification for an exterior retrofit?

2. What type of house can be considered not suited to an exterior retrofit?

3. Describe what aspects of the house exterior might need to be altered before beginning an exterior retrofit.

4. If you wish to install a new air-vapour barrier on the exterior of an RSI 2.1 wall, how much insulation is required to ensure that condensation will not occur outside of the vapour barrier at -40°C?

5. State two reasons for not using standard (4 mil) polyethylene for exterior retrofitting.

6. Describe two framing systems which can be used to accommodate RSI 4.9 fibreglass batt insulation in a curtain wall assembly.

7. What potential "weak spots" exist in the house envelope if a complete exterior retrofit is not performed?

8. Describe the requirements for window detailing as part of an exterior retrofit.

9. What are the advantages/disadvantages of performing an exterior reinsulation of a house roof?

10. Detail air-vapour barrier placement at the junction of the curtain wall and new roof assembly.

11. Calculate the energy savings resulting from the following improvements to a Whitehorse dwelling (6400 DD).

Component	Area	Pre-Retrofit	Post-Retrofit	Savings (GJ)
Walls	95.6 m^2	RSI 2.1	RSI 7	
Roof	140 m^2	RSI 2.1	RSI 9.1	
Air Change	415 m^3	.8 ACH	.2 ACH	
Windows	10 m^2	RSI .32	RSI .44	

12. State the implications of an exterior retrofit on house air quality and air quantity.

13. What alterations to the combustion and ventilation equipment might be required?

14. Describe the operation of an air-to-air heat exchanger, its benefits and limitations.

15. What are the potential implications of an exterior retrofit on the sizing of the house heating system?

Audio Visuals

WINDOWS

1	Heat loss mechanisms through windows
2	Effective R values of different glazings
3	One means of incorporating quadruple glazing
4	Fixed windows are best from an air leakage standpoint
5	Double hung windows are bad
6	Horizontal sliders are the worst
7	Best approach involves main part of window fixed, awning or casement operation
8	Positive clamping mechanism
9, 10, 11	Upgrading single glazed windows; bedding glass onto glazing tape
12, 13, 14, 15	Installing sleeve of poly around window frame before installation
16	Finishing air-vapour barrier in house
17	Using vinyl duct tape to seal against air infiltration
18	Get rid of unused windows

HUMIDITY AND CONTROLLED AIR MANAGEMENT

1	Graphic of relative air leakage characteristics of new houses. Super-insulated retrofits can approach an average of 1.5 ACH.
2	Testing equipment - depressurization fan
3	Calibration equipment - allows readings in ACH and ELA.
4, 5	Signs of excessive humidity - rotting sills, mould in corners
6	Causes of humidity - cooking, boiling water
7	Humidifiers on furnace
8	Watering plants
9	Schematic of humidity control - exhausting moist air through heat exchanger to outside
10	Schematic flow across heat exchanger
11, 12	Conventional heat exchangers
13	Poorly positioned heat exchange vents in too close proximity to dryer exhaust
14	Indication of back puffing on oil furnace
15	Schematic showing ducting for exterior combustion air
16	Enclosed furnace room
17	Ceiling fan to relieve stratification
18	Return air duct located at upper extremity of house
19	Between floor fan for controlled air flow
20	Thermostat controls

ATTIC AND CEILING INSULATION

1, 2 3	Stages of blown in insulation using either cellulose or fibreglass
4	Laying batts of fibreglass insulation - two layers of batt insulation at perpendicular
5	Air sealing attics from above - styrofoam insulation cut, fit and caulked between joists and rafters
6	Poly laid over top of ceiling joists and carefully sealed
7	Cellulose insulation blown in above polyethylene to meet, as a minimum, the 1/3-2/3 rule of thumb
8	Air sealing an attic hatch
9	Details allowing for continuous air-vapour barrier through partition walls
10	Polyethylene sleeve extending over top plate of partition wall
11	Proper sealing of air-vapour barrier: caulking laid over solid backing
12	Cross strapping of ceiling to ensure no damage to air-vapour barrier
13	Interior cathedral ceiling in good repair - best to insulate from exterior
14, 15	Extending rafter cavities of cathedral ceilings with new interior studdings
16	Use of chicken wire to ensure adequate ventilation between insulation and roof sheathing
17, 18 19	Cross strapping and dropping of horizontal nailing bars to allow extra insulation

WEATHERIZING/AIR SEAL

1, 2	Frost buildup in attics emphasizes the importance of air-vapour barrier from a structural perspective
3	Fan depressurization equipment
4	Small crack at top plate of partition wall leads to . . .
5	frost boil
6	Air leakage routes in attic - partition walls, etc. You will need to pull back existing insulation.
7	Recessed light fixtures in attic - uninsulated and not sealed
8	Proper sealing around house attic/stovepipe
9	Air leakage at sill plate being located with smoke pencil
10	Masonry/wood joint being caulked
11	Sealing of ash clean out in basement
12	Air leakage around plumbing line passing through basement wall
13	Conventional 'non-sealing' of windows
14	Use of duct tape to seal between window frame and rough stud opening
15	Weatherstripping parting rail of double hung window
16	Sealing pulley hole after removing sash weight
17	Air leakage through older door
18	Use of mailbox allows mail slot to be sealed
19	Air leakage at baseboards
20	Corner round removed, air leakage
21	Sealing with polyurethane foam
22	Commercial foaming application
23	Foam gasketing over electrical outlets

24	Poorly sealed plumbing stack
25	Air leakage at ceiling fixture
26	Air leakage at bathroom light
27, 28	Materials used in air sealing

WOOD HEATING

1	Season dried wood
2	Fireplace with heatilator
3	Air leakage around glass doors
4	Air-tight stove with proper clearances
5	Stove in corner reduces radiant heat gains
6	Air-tight stove, ceiling fan to reduce stratification
7	Creosote buildup in stovepipe
8	Causes of creosote formation
9	ULC listing on stovepipe
10	Proper stovepipe installation
11	Cleaning of flue pipe with metal brush
12	Clay lined or metal chimneys
13	Wood-oil furnace
14	Jet stream furnace
15	Pelletized wood being used as fuel for wood furnace

INTERIOR WALLS

1	Framing a new interior wall
2	Installing batt insulation
3	Importance of continuous air-vapour barrier
4	Polyethylene sleeve behind partition wall
5	Sleeve over top plate of partition wall
6	Continuity of air-vapour barrier
7, 8	Styrofoam SM as seal between joists
9	Caulking of air-vapour barrier
10	Caulking bead requires solid backing
11	Sealing details around windows
12, 13	Alternative techniques for sealing aorund electrical boxes
14	Schematic of cross strapping
15, 16	Installing horizontal 2 x 2's.
17	Ease of installing wiring
18	Unnecessary puncture of air-vapour barrier
19	Sealing between joists
20	Insulation between cross strapping

MOVABLE INSULATION

1 SM interior storm window

2 Rigid interior storm - Magnetite

3 Window quilt

4 Howland House variations

5 Enershade insulating shade

6 Hinged, rigid insulating shutter

7, 8 Rolling, insulated core device

PASSIVE

1 Importance of overhang

2 Shading effect

3 Masonry floor for heat storage

4 Adding south glass as part of renovation

5 Trombe wall retrofit and greenhouses

6 Direct gain retrofit

EXTERIOR INSULATION

1	Older house "winterized"
2	Conventional exterior insulation with rigid foam - minimal insulation
3	Cross strapping over new air-vapour barrier
4	Stages of exterior curtain wall
5	Schematic of air-vapour barrier installation
6, 7	Wrapping house with 6 mil polyethylene
8	House wrapped and truss framing
9	Schematic of curtain wall
10, 11	Base plate assemblies
12	
13	Schematic
14	Framing wall on ground
15	Carrying sections into place
16, 17	Framed walls
18, 19	
20	Schematic of insulating stages
21	First layer of insulation
22	Second layer of insulation
23	Sheathing schematic
24, 25	Sheathing exterior walls
26, 27	Finishing details of re-wrapped houses
28, 29	
30	
31, 32	Schematics of exterior roof insulation
33, 34	Newly framed cathedral ceiling
35	

36 Stand-offs for roof rafters over new air-vapour barrier

37 Framing for roof reinsulation

38 Finished house wrapped both walls and new roof

HEATING SYSTEMS

1	Schematic of furnace, distribution and controls
2	Old oil burning furnace
3, 4	Furnace mechanic performing instrumented tuning of heating plant
5	Checking pressure guage on oil
6	Setting high/low limit on boilers
7	Limit switch for fan on forced air furnace
8, 9	Cleaning out ash pit on furnace
10	Adjusting barometric damper
11	Adjusting fan belt on blower
12	Clean and dirty air filter
13	Checking expansion tank on boiler
14	Checking pump on hydronic oil heating system
15	(BLANK)
16, 17	Taping seams in ductwork with vinyl tape
18	Insulating ductwork in unheated areas
19	Poorly sealed duct end
20	Adjusting dampers to balance heat distribution
21, 22 23	Contructing an enclosed furnace room with exterior combustion air
24, 25 26, 27	High efficiency heating systems
28	Insulating tank on DHW
29	Enerstat-programmable thermostat

BASEMENTS

1, 2	Excavating for basement insulation
3, 4	Installing skirt insulation
5, 6	Insulation requires protective covering
7	Schematic of full exterior basement insulation
8	Lath installed over insulation material
9	Gripcon fastening system
10	Insulok fastening system
11	Finished exterior foundation wall
12	Interior insulation using rigid foam boards and strapping
13	Interior framing and moisture barrier
14	Batt insulation
15, 16	Insulating and sealing of floor joist cavities
17, 18	
19	
20	Insulating gaps in foundation wall
21	Insulating above crawl space
22, 23	Laying new air-vapour barrier before subflooring
24	
25	Insulating ductwork in unheated areas
26, 27	Laying insulation and new slab in house basement
28	

Make The Most Of Your Heating System

Slide Show

Prepared for Ministry of Municipal Affairs and Housing

Prepared by Renewable Energy in Canada

February 28, 1983.

MAKING THE MOST OF YOUR HEATING SYSTEM

INTRODUCTION

1. Title

Today I am going to talk to you about your heating system. How to make it operate more efficiently to save energy and money and how to make your house more comfortable.

From our conservation efforts over the last 10 years we are learning that for best and most effective results these conservation components should be co-ordinated.

1ST AIR LEAKAGE

2. Air leakage

For example: for most homeowners, the first effort should be to reduce uncontrolled air leakage into and out of the house. This makes the house more comfortable, reduces fuel bills and reduces the chances of condensation occurring in the walls and attic.

3. Poster

In 1981, the Ministry of Municipal Affairs and Housing ran a very successful air-sealing demonstration project which showed homeowners and industry in 4 cities in Ontario the importance of caulking and weatherstripping as a first step in conserving energy in the home.

4. Literature

The theme, "First, Seal Your House," was followed up with posters, booklets and factsheets which provided homeowners with the knowledge required for the best way to tackle the task.

5. Window

Air tightening involves sealing the obvious leaks around windows, doors and baseboards, but also means identifying and sealing the more obscure leakage points, especially in the basement and attic.

6. Basement

2ND INSULATION PRIORITIES

7. Wall Insulation

After reducing air-leakage, the next priority is to insulate those areas where it is most cost-effective. The basement is often a top priority area for insulation as is the attic and any uninsulated walls. Using the right material for the job ensures long-lasting and effective energy savings. If you are renovating you have an opportunity to go a step further and install high levels of insulation and a new air-vapour barrier, either on the inside or the outside of the house, depending on the type and extent of your renovation.

8. Interior Insulation

9. Exterior Insulation

10. Howland House

As a demonstration of "Conserving Energy When You Renovate" the Ministry of Municipal Affirs and Housing renovated Howland House near downtown Toronto, which is open to the public. As well as providing a demonstration of methods used to achieve 90 per cent fuel savings, Howland House, in co-operation with the Ministry of Energy, is used as a centre for the "ECCO Group" - the Energy Conservation Community Outreach Group - which offers information and assistance on the how-to of saving energy to local homeowners, retail outlets, churches, and other institutions.

11. Info at Howland

3RD HEATING SYSTEMS

12. Howland furnace area

In addition to air-sealing and insulating programs, another important step is to focus attention on the savings available by concentrating on improving heating systems.

Many of us have treated heating systems much like we may have treated our cars: ignoring them until something goes wrong. Much of this attention that has been placed on heating systems has been focussed on conversion programs.

But there is so much more that can be done to ensure that you are achieving

maximum energy-efficiency and improved home comfort.

GOVERNMENT GOALS

13. Heating Systems poster

This new demonstration project, "Make the Most of Your Heating System" is a further step in achieving goals set by the Government of Ontario for improving the energy-efficiency of the average Ontario household. These goals include a reduction of 30% in total residential energy demand from 1980 to 1995 and, by 1990, a reduction in residential oil use to 10% of the total residential sector energy requirements.

YOUR HEATING SYSTEM

14. System Graphic

A key word in this project is the word "system". This implies much more than the furnace itself. Controls and the distribution system, whether fans and ducts for forced air, or pumps and pipes for hot water, play a major role in both the efficiency and comfort of your home.

MAINTENANCE (PHASE I)

15. Maintenance

All heating systems, whether oil, gas, or electric, require ongoing maintenance.

16. Service man

A regularly-scheduled proper furnace servicing is the cornerstone of an effective maintenance program.

17. Instrumented tuning

The best servicing involves an instrumented tuning of the burner. This is more comprehensive than regular tuning and involves smoke tests (using a hand pump) and chimney draft measurements. A regular servicing also includes an

18. Fan Belt

inspection of the electrical connections, fan belt, and for oil systems, the oil filter and oil nozzle.

19. Cleaning Chamber

At the same time, various parts should be cleaned or vacuumed, including the exhaust breeching, barometric damper,

20. Filters	stack controller, heat exchanger, fanblades, burner fan and, of course, cleaning or replacing the filters.
21. Checking Chimney	The chimney and chimney base both inside and outside are also checked for blockage
22. Limit Controls	or deterioration. The high limit of the safety controls, seal of the panels, the furnace casing, fuel lines and storage are also examined to ensure that everything is in order.
23. Hot water/boiler	Boiler systems require regular servicing in the same manner. In addition, there are other items that require special attention such as: draining the expansion tank, bleeding air from the radiators, and lubricating the water circulation pump.
24. Service man	There is a lot to look at and a thorough cleaning and tuning of an oil system, for example, can require two hours. It can also reduce your fuel consumption by as much as 10 percent compared to a poorly maintained unit.
25. Ductwork	One of the most neglected aspects of a forced-air heating system is the distribution network. In a recent Ministry study of 10 homes with forced-air, on average, only a third of the heat which left the furnace got to the heating registers in the rooms! The range was from 8% to 54%.
26. Leaky, uninsulated ducts	The problem is that ducts are uninsulated and leaky and so much of the heat is spilled into the basement and walls.
27. Register adjustment	In addition, many systems are poorly balanced, which means that some parts of the house have to be overheated just to get enough heat to other parts.
	The Ministry's project "Make the Most of Your Heating System" has been established to discover how much homeowners can expect to save by maintaining an efficient heating system.
28. Checklist	In Phase I of the project, which goes

until this spring (1983), a "checklist" for heating systems will be developed. Twenty houses will be tested, serviced, and tuned and then monitored over the remainder of this heating season. Fuel consumption before and after will be compared.

PHASE II

29. Serviceman

In Phase II, which will go through the '83-'84 heating season, more substantial retrofit measures may be undertaken. Each house will be analysed individually for the most appropriate measures for that house. It is expected that these measures will cover the wide range of options that now face the typical homeowner.

UPGRADE

30. Taping ducts

31. Insulating ducts

It is expected that work will be required on the distribution system: such as sealing leaky ductwork; replacing and insulating improperly sized ducts or installing operable dampers.

32. Installing pump

In some cases it will mean installing pumps or fans in old gravity-fed systems or enlarging the blower capacity of others.

33. Enerstat

Thermostats will often work better in a new location, away from other sources of heat, such as the sun or lights, or they may be replaced with a programmable type that automatically sets the temperature back during those times when no one is home.

34. Solinoid Valve

Some furnaces will need to be upgraded. For oil systems that are relatively new and in good condition this may mean downsizing to a more efficient burner size or adding a retention head, solinoid valve, or flue damper.

REPLACE

35. Old furnace

If an oil or gas system is in poor shape or the furnace is over 15 years old, it should be inspected because it may not be worth upgrading.

Going "off-oil" presents several options, including wood, solar or propane; however, the two most common choices are natural gas and electricity.

36. Upgrading service panel

Switching from one fuel source to another often has other implications. For example, switching to electricity may require you to install a service entrance larger than you presently have or switching from oil to natural gas may require you to install a chimney liner.

NATURAL GAS

37. Gas conversion burner

Converting to natural gas is the most popular choice. If your oil furnace was designed for conversion, you can replace just the oil burner with a gas burner. For higher efficiency, you can install a gas burner with electronic ignition.

38. Vent damper

Alternatively, you can replace the entire furnace with a new gas one. Many new gas furnaces have energy saving features you should look at. These include electronic ignition and an automatic vent damper. The vent damper closes off the chimney when the furnace is not operating and reduces warm air losses.

39. Condensing gas furnace

Recently there have been a number of new generation, super-efficient gas furnaces and boilers made available. These operate without a chimney. Instead, the products of combustion are exhausted out the side of the house through a small vent. The most efficient units have a condensing heat exchanger that extracts so much heat from the gases that water vapour condenses out and drains to a floor drain.

These units operate at efficiencies over the heating season of about 90%, compared with conventional units that have seasonal efficiencies of 60%.

40. Hydropulse boiler

There are many types of super-efficient units on the market. Some burn the fuel in a series of pulses, some draw their combustion air from outside, while others place the entire unit outside the house.

Some of these units are available to run on propane. This can be a good stop-gap measure if natural gas isn't available in your area, but is expected to arrive sometime in the future.

ELECTRIC HEATING

In areas not serviced by natural gas, many people are switching to electric heat.

41. Plenum heater

Sometimes this involves a partial switch, by installing a plenum heater. During the warmer periods of spring and fall, the system works on electricity. During the colder periods, when the oil furnace will operate more efficiently because of a longer burning time, the oil furnace is used.

42. Electric furnace

Electricity can entirely replace a system by installing an electric furnace or boiler or electric baseboard heating.

43. Heat pump

Another option is the all electric heat pump. These units can assist in winter heating. The are expensive to install, but may be worthwhile if air conditioning is required.

SUPPLEMENTARY SYSTEMS

44. Wood stove

Wood burning is becoming more popular as a supplementary heat source. Wood heating is most appropriate if you have access to wood at reasonable prices, if you install and operate the system in a safe manner, and if you prefer the exercise over the convenience. You

should check with your insurance company since it may affect your home policy.

45. Wood oil furnace

The two most common systems are the air-tight wood stoves and wood furnaces. Some combination furnaces will automatically switch to an alternative fuel, such as oil or electricity, when the wood fire dies down.

46. Kerosene heater

Kerosene heaters are sometimes used to heat cold or hard-to-heat areas. Cold rooms can often be remedied by balancing the heating system. Where kerosene heaters are used, the kerosene should be stored safely and the heater should not be used in an unventilated space and care should be taken in its operation.

SAFETY

47. Safety

Safety should always be the first priority when inspecting, tuning, or working on your heating system.

All conventional heating systems are safe when operating properly. However, changing part of the system, or even renovating your house, can affect how your heating system operates. All fuel-burning systems require adequate combustion air. Air is used to both burn the fuel and to vent the products of combustion out of the house.

48. Back-puffing sympton

Sometimes a furnace is starved for air; back puffing is one indication of this problem. This usually occurs because air is being rapidly expelled from the house through other routes, such as a roaring fireplace or stove, or exhaust fans running continuously. These forces can actually pull air down the chimney, even when the furnace is operating. If a problem persists you should open a window or install a combustion air duct. Also, fireplaces should either be supplied with outside combustion air or you should open a window near the fireplace when it is operating.

49. Combustion air

50. Deteriorated chimney

Another safety consideration is the state of the chimney. Condensation can quickly deteriorate masonry chimneys, causing debris to accumulate. Signs of condensation can be white powder or stains on masonry chimney bricks or water seepage, black stains or broken brick at the clean-out door.

51. Chimney liner

These problems appear most often where a house has converted from oil to gas. The solution to this condition is usually installing an approved chimney liner.

INFORMATION

52. Anytown, Ontario

Keeping warm and comfortable in the most energy-efficient manner, while maintaining high safety standards, is at the heart of our program "Make the Most of Your Heating System".

53. Credits

The Ministry of Municipal Affairs and Housing, in co-operation with the Town of Vaughan and the Ministry of Energy, is developing a co-ordinated program which will include workshops, audio-visual shows, a technical training course, booklets and studies. The demonstration project being undertaken in the town of Vaughan is at the core of this program. The results of this study will be used throughout Ontario as an example of the wise use of our energy resources.

POOR

QUALITY

ORIGINAL